International Journal of Engineering and Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 15 Issue 1 January 2026 || PP 12-18

The Impact of Digital Transformation on the Export Capacity of Vietnam's Seafood Industry

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ABSTRACT : *This study utilizes a panel dataset of 30 Vietnamese provinces (2020–2024) to examine the impact of digital transformation (DTI) on seafood export performance using a Fixed Effects model. The empirical results reveal a significant positive correlation, where a 1unit increase in the DTI score leads to a 0.74 unit rise in export turnover, underscoring DTI's role in overcoming technical barriers like the IUU "Yellow Card". Conversely, the model identifies a structural shift, as labor quantity shows a negative impact, suggesting a transition from labor-intensive to technology-driven growth. Ultimately, the findings confirm that digitizing infrastructure and enhancing digital skills are now more critical for export competitiveness than raw productivity or labor scale.*
KEYWORDS *- Digital transformation, export capacity, Vietnam's seafood industry, Vietnam.*

Date of Submission: 06-01-2026 Date of acceptance: 16-01-2026

I. INTRODUCTION

In the era of the Fourth Industrial Revolution, digital transformation has emerged as a decisive factor in redefining the competitive landscape of Vietnam's seafood exports. As global markets impose increasingly stringent standards on traceability and sustainability, particularly the IUU "Yellow Card" from the European Union, traditional production models are facing significant bottlenecks. This research explores the critical nexus between digital policy integration and national export capacity within this high-pressure environment. By identifying how technological advancements can mitigate trade barriers and optimize resource allocation, the study provides a strategic framework for the sustainable international integration of the fisheries sector.

1.1. Overview of Digital transformation and Export Capacity

Conceptual Framework of Digital Transformation

The most prevalent and widely accepted academic definitions of Digital Transformation (DT) typically focus on strategic and comprehensive change. According to Westerman, Bonnet, and McAfee (2014), Digital Transformation is the use of emerging technologies (social, mobile, analytics, and cloud) to enable major innovations in operational performance and business models. DT requires a combination of "digital intensity" namely, technological investment with strategic management. This research shapes the concept of DT as a strategic business and management phenomenon, rather than a purely technological issue.

Furthermore, Hess, Benlian, Matt, and Wiesböck (2016), in their work "Digital transformation strategies: A framework for strategy assessment," define DT as a fundamental shift in strategy and organization. Specifically, they state that "Digital Transformation is a process that involves changes which digital technologies can bring to a company's business model, resulting in shifts in products or organizational structures."

However, within the research context of strategic management and international trade for the 2020–2025 period, digital transformation (DT) is positioned as a Dynamic Capability (DC). The DC theory extends the Resource-Based View (RBV) by focusing on a firm's ability to reconfigure and integrate resources to adapt flexibly to global market fluctuations. To become a core competency, DT must be utilized to build digital assets that satisfy the VRIN criteria (Valuable, Rare, Inimitable, and Non-substitutable).

Concepts of Export Capacity

There are various conceptualizations of export capacity. Specifically, according to the IMD World Competitiveness Center, the definition focuses on market performance and the ability to meet the diverse requirements of international customers:

"Export capacity is the ability of domestic companies to produce and sell goods and services abroad that meet international criteria for quality, price, and other standards, leading to an increase in global market share."

Michael Porter defines competitiveness more broadly than export capacity, yet his framework remains highly applicable to exporting as follows:

"Competitiveness is the ability of a nation to achieve and sustain success in international trade with high levels of productivity, thereby generating high and stable real income for its citizens in the long run."

1.2. Theoretical Frameworks

There are four theoretical frameworks: Resource – Based view (RBV); Dynamic Capabilities theory; Porter's Diamond Model and Technical barriers to trade (TBT) and sanitary and phytosanitary (SPS).

Firstly, RBV focuses on internal resources as the primary source of competitive advantage, specifically digital transformation (DT) is viewed as a strategic digital resource that enables seafood exporters to achieve superior performance.

Secondly, dynamic capabilities theory: An extension of RBV that explains how firms adapt to rapidly changing environments. Digital tools allow firms to sense international market shifts (IUU regulations) and reconfigure their supply chain to comply.

Thirdly, Porter's diamond model. This model analyzes why certain industries in a nation are competitive internationally based on four attributes and the role of government. It also explains how government policies on digital transformation act as a catalyst for the seafood sector's export capacity.

Last but not least, technical barriers to trade (TBT) and Sanitary and Phytosanitary measures (SPS): focusing on the impact of technical regulations and standards on international trade flows. The "IUU Yellow Card" serves as a TBT. Digital transformation (VMS, traceability) is the primary mechanism to mitigate these barriers.

1.3. The relationship between digital transformation policy and export performance

The relationship between digital transformation policy and export performance in the seafood industry is multi – dimensional. It operates through various transmission channels, ranging from macro – level governmental management to micro – level corporate capabilities.

The first, reducing transaction and operational cost: Digital transformation policies facilitate the digitalization of administrative procedures and trade processes: (1) Reduction in compliance costs: implementing online public services and digital customs systems helps businesses save time and paperwork cost during export fulfilment; (2) Supply chain optimization: Policies encouraging the application of IoT and AI in logistics allow firms to track orders in real – time, minimizing the risk of spoilage – a critical factor for perishable seafood products.

The second, compliance channel: Overcoming technical barriers and enhancing transparency. This is the most direct impact channel given Vietnam's current efforts to remove the "IUU Yellow Card". Specifically, origin transparency: Mandatory policies for installing vessel monitoring systems (VMS) and developing national databases like VN Fishbase provide verifiable proof of the legal origin of products; Meeting international standards: Digital transformation assists enterprises in obtaining digital certifications for food safety and sustainability. This directly enhances export capacity to stringent markets such as the EU and the US.

Last but not least, Value – added channel: Shifting from quantity to Quality. Digital transformation shifts the export product structure from "raw" to "deeply processed" goods, specially (1) Improving productivity (yield): The application of digital technology in aquaculture (smart farming) allows for better control of water environments and disease reduction, thereby improving the quality and size of export products; (2) Direct market access: Policies supporting cross -border ecommerce enable seafood enterprise to reach foreign distributors directly, bypassing intermediaries. This increases profit margins and prices competitiveness.

Table 1.1. Summary of Conceptual Relationships

Digital Transformation Policy	Impact on Export Capacity	Transmission Mechanism
Digital infrastructure support	Positive (+)	Increase traceability and transparency
Digitalization of Admin Procedures	Positive (+)	Reduces transaction costs and customs clearance time
Digitalization of Admin Procedures	Positive (+)	Enhances labor quality; replaces manual labor with technical expertise
Digital skills training	Positive (+)	Expands customer networks and reaches new markets.

Sources: Complied by the authors

2. Current state of Vietnam's seafood export turnover over the period 2020-2025

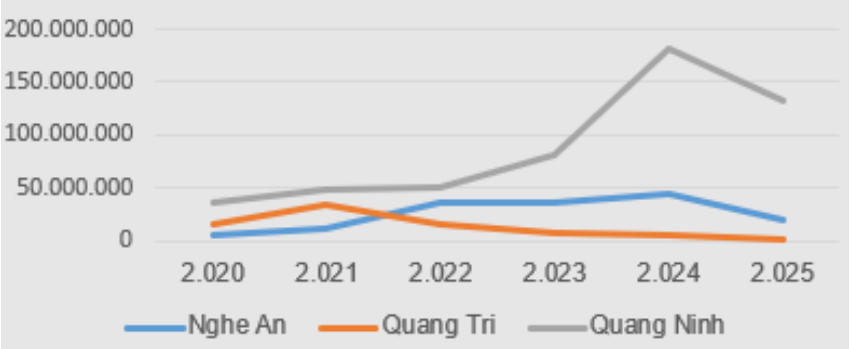

Figure 2.1: Total seafood export turnover in Group 1 from 2020 to 2025

Unit: USD

Sources: General department of Vietnam Customs

Look at the diagrams, we can divide into three groups: Firstly, the outlier of the growth group is Nghe An province. This is the most exceptional case, with a growth rate in 2022 reaching 341% (a 4.4. fold increase over the previous year), it aligned with the "record - breaking" year for Vietnam's seafood industry (surpassing 11 billion for the first time). These are some reasons for this scenario: (1) post COVID-19 recovery: In 2021, Nghe An was severely affected by the pandemic and supply chain disruptions. In 2022, upon reopening, inventory and production capacity were fully unleashed; (2) Boosting from deep processing: During this period, Nghe An focused heavily on seafood processing plants in industrial zones (such as Dong Hoi and Nam Can). Instead of exporting raw products, the shift to value-added goods (processed shrimp, canned fish) drove export turnover (USD) upward, even if volume did not increase proportionally; (3) High global prices: In 2022, global shrimp and pangasius prices peaked due to global supply shortages, allowing the province's export enterprises to earn breakthrough profits. Secondly, Quang Tri province was strong growth in 2021 (230%), then followed by a decrease in 2022. Particularly detailed causes: (1) "Against the tide" strategy in 2021. While many southern provinces closed due to social distancing, central provinces like Quang Tri maintained "green zones" for production for an extended period. This allowed Quang tri to capture orders that shifted away from the south; (2) High- tech shrimp farming projects: The 2020 – 2021 period made the time when high-tech farming areas in Vinh Linh and Gio Linh began harvesting at scale, with yields higher than many times traditional farming. Following this period of "hot" growth, Quang Tri faced climate change and shrimp diseases in 2022, coupled with skyrocketing logistics costs (fuel, containers), which narrowed the growth margins. The last but not least, Quang Ninh provinces. This is a typical case of "overcoming adversity". The number of export growth experienced nearly a double in late 2023 and early 2024, because of restructuring after natural disaster. Quang Ninh implemented a revolution in "sustainable sea farming", replacing foam buoys with sustainable HDPE plastic. This standardization helped products meet export standards for demanding markets (EU, Japan), increasing order value. Additionally, shift from informal to formal exporting and Industrial-scale sea fish farming are main reasons to boost productivity.

In conclusion, all three provinces demonstrate a shift from "natural exploitation" to "high – tech aquaculture" and "deep processing", adaptability.

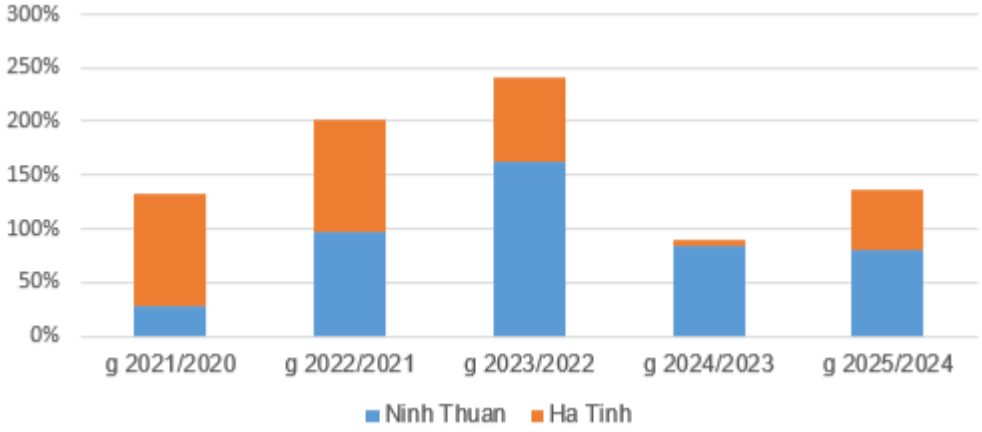

Figure 2.2: YoY export growth rate for group 2

Unit: %

Sources: General department of Vietnam Customs

The second group is "Outliers with negative growth". Based on the data for Ninh Thuan and Ha Tinh, combined with the local economic realities in Viet Nam. Firstly, the 72% drop compared to 2020 in Ninh Thuan during 2021 represents a severe disruption, which can be attributed to the following factors (1) Epicenter of the 4th COVID-19 wave: South-Central and Southern provinces were heavily impacted by strict lockdowns under Directive 16. Ninh Thuan, where seafood processing enterprises are concentrated in industrial zones, faced severe labor shortages due to quarantine measures and the high costs of "on-site" production (3-on-site), forcing many factories to suspend operations; (2) Disruption of shrimp seed and commercial shrimp chains: Ninh Thuan is the "capital" of shrimp seeds in Vietnam. Restrictions on inter-provincial movement in 2021 brought the transportation of shrimp seeds and export seafood products to a complete standstill at gateways, leading to a deep plunge in export turnover; (3) Frozen consumption markets: Main export markets for Ninh Thuan faced international logistics difficulties at the time (container shortages, skyrocketing freight rates), preventing goods from being exported on schedule.

Ha Tinh province witnessed "shock" decline in 2024 just only 6%. The growth rate of only 6% compared to 2023 is a "red alert" signal for Ha Tinh's seafood industry, resulting from several realities: (1) Consequences of the IUU yellow card: Ha Tinh has a large fishing fleet, but managing the installation of Vessel Monitoring Systems (VMS) and logging fishing diaries faced many challenges. 2024 was a critical year for EC inspections to decide whether to lift or maintain the yellow card. Tightened management led to a sharp decrease in the volume of seafood eligible for export to high-end markets like the EU; (2) Disease in shrimp farming: Ha Tinh has a massive area dedicated to sand-based shrimp farming. In 2024, climate change and water pollution in key farming areas (such as Nghi Xuan and Cam Xuyen) caused widespread disease outbreaks, severely damaging the province's primary export shrimp output.

Last but not least, Group 3: "Sustainable Stability" including Ca Mau, Soc Trang, Kien Giang and Khanh Hoa. The steady growth observed in these provinces-even during periods of global volatility can be attributed to the following core pillars:

(1) Ca Mau; Soc Trang: "Shrimp Capitals" with Integrated Value Chains These two provinces consistently lead the country in shrimp export turnover. Their stability stems from: Diverse Farming Models: Ca Mau excels in eco-friendly shrimp farming (mangrove-shrimp and rice-shrimp models) with international certifications, while Soc Trang is a powerhouse in high-tech, intensive, and super-intensive shrimp farming. This ensures a steady supply for demanding markets like the US, Japan, and the EU; Deep Processing Capacity: These provinces host Vietnam's largest seafood corporations (such as Minh Phu and Stapimex). Their advanced processing facilities focus on value-added products, which helps maintain export turnover even when raw shrimp prices fluctuate.

(2) Kien Giang: Diversified Supply (Capture Fisheries & Aquaculture) Kien Giang possesses unique strategic advantages that minimize risks: Vietnam's Largest Fishing Fleet: Beyond aquaculture, Kien Giang owns a massive offshore fishing fleet. The combination of captured seafood (fish, squid, octopus) and farmed shrimp creates a "risk-offsetting" effect; if one commodity faces difficulties, another can compensate; Climate Change Adaptation: Kien Giang has aggressively transitioned to coastal rice-shrimp models, stabilizing production output despite increasing saltwater intrusion.

(3) Khanh Hoa: Hub for Tuna and High-End Seafood Unlike the Mekong Delta provinces, Khanh Hoa follows a specialized path: Tuna Dominance: It is the largest tuna processing and export hub in Vietnam. The tuna market typically maintains high value and stable demand in markets like the US and the Middle East; Industrial Marine Farming: Khanh Hoa leads in industrial-scale marine cage farming (seabream, pompano) and high-end seafood like lobster; Logistics Infrastructure: Major seaports and large-scale cold storage facilities in Khanh Hoa optimize costs and ensure a steady export flow year-round.

In conclusion, the stability of this group serves as the "backbone" of Vietnam's seafood industry: Resilience; Export and Strategic planning.

II. Research Results

3.1. Data description and research methodology

This study employs a panel dataset covering 30 provinces and cities over the period 2020 – 2024 (yielding a total of 150 observations). The regression model is specified in a log-log functional form to minimize potential biases and the impact of outliers

Model Specification and variable definitions

The empirical model is specified as follows:

$$\ln(EXPORT_{it}) = \beta_0 + \beta_1 \times DTI_{i\,t} + \beta_2 \times \ln(YIELD)_{\ it} + \beta_3 \times \ln(LABOR)_{\ it} + e_{it}$$

Variable definitions:

+ $\ln(EXPORT_{it})$: The natural logarithm of the seafood export value for province I in year t

+ $DTI_{i,t-1}$: The digital transformation index (DTI) of province i in year t-1. This represents the one – year lagged variable of the policy proxy.

+ $\ln(YIELD)_{\ it}$: The natural logarithm of total seafood production (Control variable for supply capacity).

+ $\ln(FIRM)_{\ it}$: The natural logarithm of the number of seafood enterprises labors in the province (Control variable for industrial scale).

3.2. Analysis of Descriptive

Table 3.1. Descriptive Statistics of Model Variables (Logarithmic Form)

Index	LOG(EX)	DTI	LOG(YIELD)	LOG(LABOR)
Mean	18.44254	0.509887	12.04971	11.03197
Median	18.70144	0.512200	12.18224	10.94198
Maximum	21.09630	0.791200	13.64284	12.72189

Index	LOG(EX)	DTI	LOG(YIELD)	LOG(LABOR)
Minimum	12.34702	0.261200	9.466609	9.942708
Std. Dev.	1.881492	0.152554	0.901206	0.628144
Probability	0.000000	0.005512	0.028312	0.000126
Observations	150	150	150	150

Source: Authors' calculations from Eviews

Analysis of Descriptive Statistics

- Export Performance (LOG(EX)): The mean value of the log of export turnover is 18.44, with a standard deviation of 1.88. The relatively high gap between the maximum (21.09) and minimum (12.34) values indicates a significant disparity in seafood export capacity among the surveyed provinces.
- Digital Transformation Index (DTI): The average DTI score across the provinces is 0.51. The index ranges from a minimum of 0.26 to a maximum of 0.79, reflecting varying levels of digital adoption across different geographical regions in Vietnam.
- Yield (LOG(YIELD)): This variable shows a mean of 12.05 and a relatively low standard deviation of 0.90, suggesting that seafood productivity is more stable and less volatile across provinces compared to export turnover.
- Labor (LOG(LABOR)): The mean log of labor is 11.03. The positive skewness (0.83) indicates that the distribution of labor is skewed toward the right, meaning a majority of provinces still maintain a high concentration of seafood labor.

3.3. Optimal Model Selection Process

This test aims to determine whether there are unique, time-invariant characteristics specific to each province (fixed effects) that influence export turnover. The null hypothesis (H_0) posits that the Pooled OLS model is appropriate for the analysis.

Table 3.2. Redundant Fixed Effects Test Results

Effects Test	Statistic	d.f.	Prob.
Cross-section F	76.078593	(29, 87)	**0.0000**
Cross-section Chi-square	392.619590	29	**0.0000**

Source: Authors' calculations from Eviews

3.4. Hausman Test (Selection between FE and RE)

Once it is determined that a panel data model is necessary, the Hausman Test is conducted to choose between the Fixed Effects (FE) model and the Random Effects (RE) model. The null hypothesis (H_0) for this test is that the Random Effects model is the optimal choice.

Table 3.3: Hausman Test Results

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	9.500613	3	**0.0233**

Source: Authors' calculations from Eviews

Analysis: The Hausman test yields a p-value of 0.0233, which is lower than the 5% significance level (0.05). This allows for the rejection of the null hypothesis (H_0), implying that there is a correlation between the unique errors (unobserved effects) and the explanatory variables in the model.

Model Selection Conclusion: Based on the results of the two aforementioned tests, the Fixed Effects (FE) model is identified as the most optimal and is selected to analyze the impact of Digital Transformation (DTI) on export turnover in this study.

3.5. Regression results and discussion

$$\ln(EX)_{it} = 40.67 + 0.74 \cdot DTI_{it} + 0.64 \cdot \ln(YIELD)_{it} - 2.75 \cdot \ln(LABOR)_{it} + e_{it}$$

Table 3.4. Fixed Effects Model Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	(Prob.)
Constant (C)	40.67421	17.61925	2.308509	0.0227
DTI (Digital transformation index)	0.738650	0.350147	2.109546	0.0370

Variable	Coefficient	Std. Error	t-Statistic	(Prob.)
LOG(YIELD)	0.644984	0.462885	1.393401	0.1661
LOG(LABOR)	-2.753829	1.575609	-1.747787	0.0831
R-squared	0.965332	F-statistic	101.8077	0.000000
Adjusted R-squared	0.955850	Durbin-Watson	1.321792	

Source: Authors' calculations from Eviews

Assessment of Model Fit

- Coefficient of Determination (R^2): The model yields an R^2 value of 0.9653. This indicates that the independent variables explain approximately 96.53% of the variation in provincial export turnover. Such a high explanatory power for panel data confirms that the model captures most of the critical determinants.
- F-Test: The Prob(F-statistic) = 0.0000, which is less than 0.05, demonstrating that the model is overall statistically significant.
- Autocorrelation: The Durbin-Watson statistic is 1.3218. Although this value is slightly lower than the ideal benchmark (near 2.0), it remains within an acceptable range for a panel dataset with a relatively large number of observations (N=150).

Discussion of Independent Variables

- Impact of Digital Transformation (DTI): The DTI variable has a positive regression coefficient (0.7386) and is statistically significant at the 5% level (p-value = 0.0370 < 0.05). This result suggests that, ceteris paribus, a 1-unit increase in a province's digital transformation index leads to an estimated 73.86% increase in the average export value. This provides strong empirical evidence for the hypothesis that accelerating the digitalization of local processes, infrastructure, and management enhances competitiveness and drives export growth.
- Impact of Labor Force (LOG(LABOR)): The regression coefficient for the labor variable is negative (-2.7538) and statistically significant at the 10% level (p-value = 0.0831). While this contradicts traditional expectations regarding labor-intensive industries, it reflects the reality of economic structural shifts. In high-export provinces, there is a strong trend toward replacing manual labor with automation technology and digital platforms. Relying solely on labor quantity without corresponding digital skills may reduce operational efficiency in the modern context.
- Impact of Yield (LOG(YIELD)): The yield variable has a positive coefficient (0.6449) but lacks statistical significance in this model (p-value = 0.1661 > 0.05). This indicates that fluctuations in crop or livestock productivity (if applicable to agricultural exports) or general productivity did not have a direct or prominent impact on export turnover compared to digital transformation factors during the study period.

IV. Conclusion and Policy Recommendations

4.1. Conclusion

By utilizing a panel dataset of 30 provinces from 2020 to 2024 and employing the Fixed Effects (FE) estimation method, this study has reached the following key conclusions:

- The Pivotal Role of Digital Transformation: The DTI index exerts a positive and statistically significant impact on export turnover. This confirms that digital transformation is not merely a trend but a direct driver helping localities optimize international trade activities.
- Labor Structural Shift: The negative coefficient of the labor variable indicates that the export model is gradually shifting from being labor-intensive to becoming technology- and capital-intensive. Merely increasing the quantity of labor no longer yields proportional export growth unless accompanied by digital process innovation.
- Explanatory Power of the Model: With an R^2 exceeding 96%, the model demonstrates very high suitability in explaining provincial export fluctuations in Vietnam through technological factors and input resources.

4.2. Policy Recommendations

Based on the empirical findings, the study proposes several recommendations to promote sustainable exports:

- Prioritizing the Improvement of the DTI Index: Provinces should concentrate resources on improving the pillars of the DTI, particularly digital infrastructure and the digital economy. Enhancing information transparency and digitalizing administrative procedures related to import-export will help businesses reduce costs and time.

- Developing a Digital Workforce: Rather than focusing on the scale of the labor force, policies should prioritize digital skills training for workers. This enables labor to operate modern production and management systems, thereby reversing the negative impact of traditional labor variables observed in the model.

- Integrating Digital Transformation with Productivity: Policies are needed to support businesses in applying digital technology directly to production processes. This aims to transform the potential of productivity (YIELD) into tangible export results, which was not clearly demonstrated during this research period.

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